

# Determination of the influence of SnO<sub>2</sub> nanowires on resistive-type gas sensors

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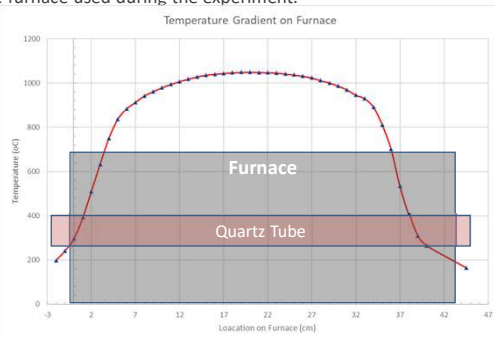
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## Synopsis

This project involved the study of metal-oxide nanowires (NW) as resistive-type gas sensors and how the fabrication method impacted the sensor's performance. The goals were to develop a method of growing ZnO NWs, determination of ideal gas sensor fabrication techniques, and analysis of SnO<sub>2</sub> NW amount on sensor performance.

## ZnO Nanowire Synthesis

The synthesis of ZnO NWs involved testing various growth substrates, furnace atmospheres, and temperature gradients between source and growth substrates. First, the temperature gradient was determined in the furnace used during the experiment.



Source Material: 0.1 g of 1:1 ratio by weight of graphite and ZnO powders.

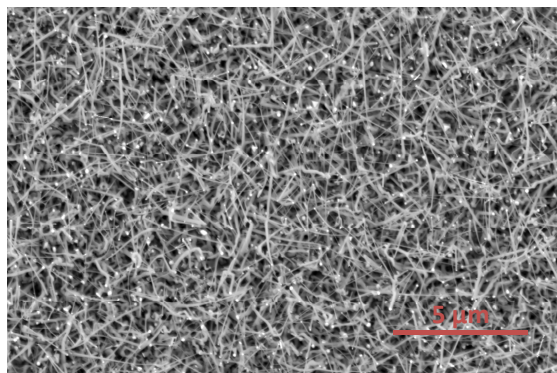
Tested Growth Substrates: (100) Si with sputtered layer of Au, and polycrystalline Al<sub>2</sub>O<sub>3</sub> substrate with sputtered Au. (Both flat and upright)

Temperature Gradient between substrate and source: 600°C

Time: 1.5 hr

Atmosphere: 50 torr, with 200 sccm Ar flow

Key developments were the use of the vacuum pump and using a sputtered Au growth substrate in an upright position.



SEM image of ZnO NWs grown via VLS

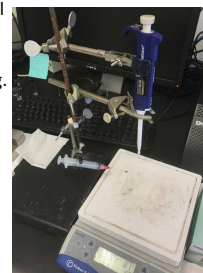
## Device Fabrication Methods

Several known fabrication methods were investigated with the goal of determining which method applied a consistent amount and accurate placement of nanowires onto the electrode substrate. Methods Tested: Solvent-free mechanical transfer and drop-casting. Results: Drop-casting most feasible based on consistency in producing functioning sensors with minimal electrode damage.

After choosing drop-casting, the solvent carrying the NWs was investigated with the goal of observing which would most accurately place the NWs.

Solvents: DI Water, ethanol, methanol, and dimethylformamide (DMF).

Results: DMF most adequate, based on evaporation time and predictability.



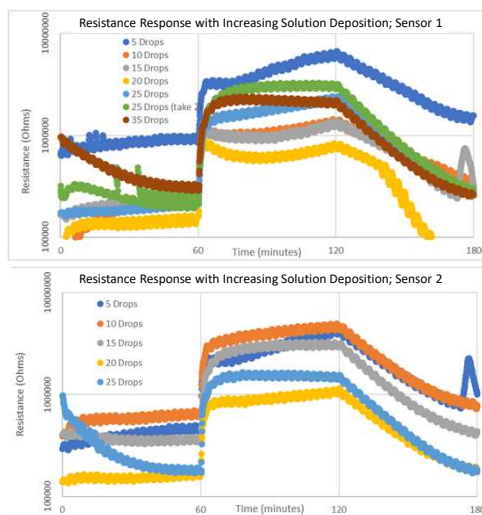
Sensor fab. Setup: blue micropipette held by lab stand, over hot plate; needle over sensor for solution accuracy

## Determination of NW Amount on Sensor Response

The final task of the project involved testing different amounts of SnO<sub>2</sub> NWs on the responsiveness of the fabricated sensors. The sensors were tested in a sealed probe station which used Au-coated W probes which sourced voltage and measured current across the sensors. Source voltage of 5V, current limit of 0.1 μA, at 350°C. Gases flowed: 1hr N<sub>2</sub>, 1hr 21% O<sub>2</sub> (simulating air), and finally 1hr of N<sub>2</sub>.

## Coverage Tests: Part 1

Using a micropipette set to 0.5 μL, the two sensors were tested after every 5 drops of solution, with the idea that as more drops were added the amount of material on the electrode would increase.

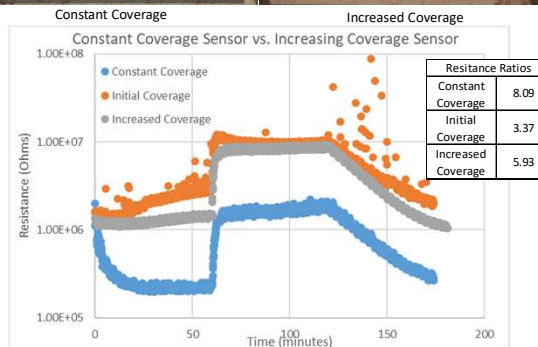


Resistance Ratios		
Drops	Sensor 1	Sensor 2
5	7.18	9.14
10	5.00	6.69
15	5.45	7.94
20	4.79	6.81
25	9.72	8.97
30	8.07	
35	7.49	

The results showed no correlation between the addition of successive drops of solution and the response value of the sensor. This meant that successive drops did not necessarily mean more material was deposited on the substrate.

## Coverage Tests: Part 2

The next approach to coverage testing involved preparing two sensors. One sensor would remain constant with respect to NW coverage, while the second sensor coverage would vary from low to high. Concept was that the sensor response would increase with increasing coverage. Observations during the experiments deviated from predicted trends, indicating the need for further testing.



## Conclusion

The objective of determining a method to synthesize ZnO NWs via VLS was achieved using a Au sputtered (100) Si substrate with a temperature gradient of 600°C between source and growth substrate. Further work investigating source and growth temperature gradients as well as the type and layer thickness of the sputtered catalyst, with the goal of producing longer and more numerous NW amounts. Although drop casting fabrication with DMF cannot be said to be the ideal method, it was determined to be adequate for this experiment. Future studies will require a fabrication method that transfers consistent NW amounts on sensor substrates. The first set of coverage tests showed that successive drops during fabrication did not correlate with the material amount on the electrode. The second set of coverage tests were inconclusive. Future tests should be run following the same procedure to produce more data to identify if in fact there is a trend to sensor response values and material coverage on the electrode substrate. Further work on the objective of this project would produce a baseline for sensor testing, for which different NW materials could be compared.

## Acknowledgements

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